

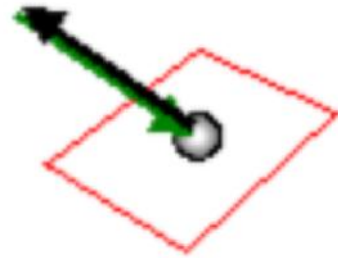


Urban Camenzind

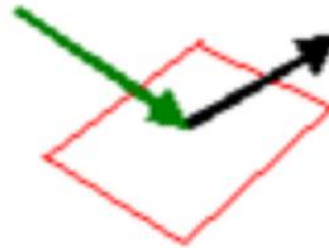
How Retro-reflectivity works



What is retro-reflectivity?



**Retro-
reflector**



**Specular
reflector**



**Diffuse
reflector**

Retro-reflectivity:

Is a property of a surface, that allows a large portion of the light coming from a point source, to be returned directly back to a point near its origin.

(Federal Highway Administration 2009)

Why worry about retro-reflectivity?



Daylight

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retro-reflectivity at work



At night we depend on retro-reflectivity for information.

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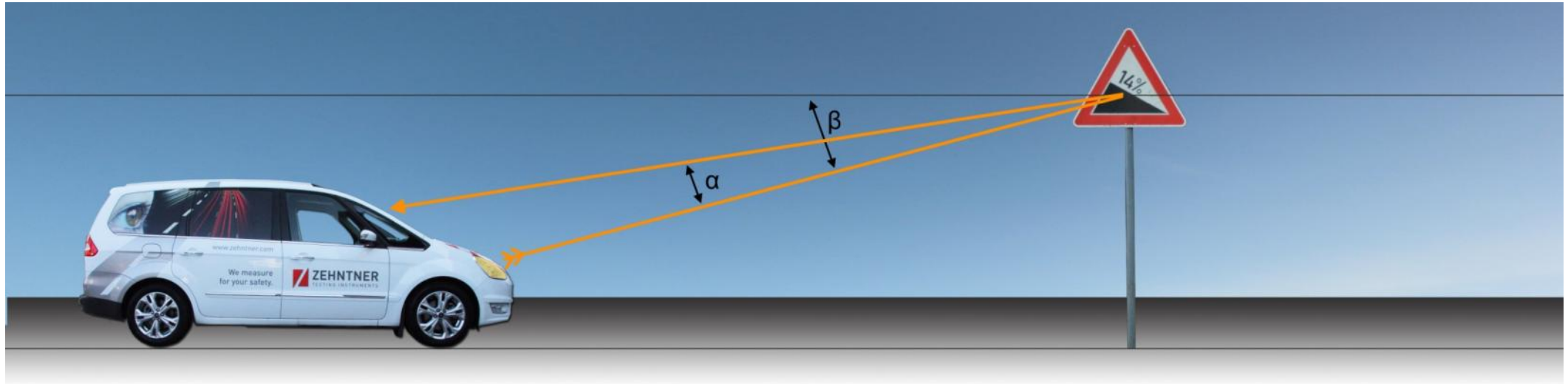
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retro-reflectivity at work



Contrast of new marking, merging with old marking
Yellow road marking produces less retroreflective than white
Yellow road marking has low contrast ratio

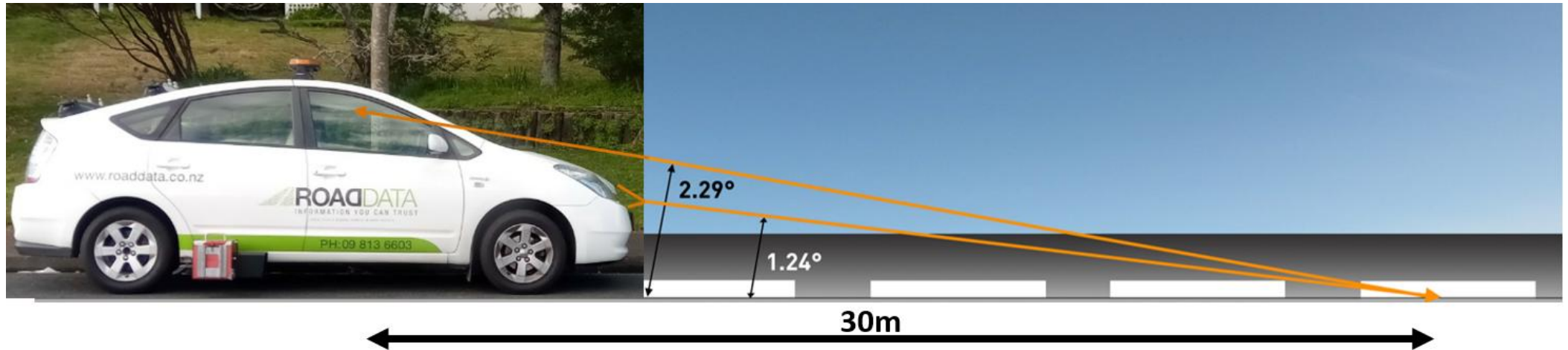
Retro-reflectivity and how it is measured



		ASTM E1709
Illumination angle β		-4°
Observation angle α		$0.2^{\circ}, 0.5^{\circ}, 1^{\circ}$

$$R_L = \text{mcd/m}^2/\text{lux}$$

Retro-reflectivity and how it is measured



EN 1436 Standard R_L

night time retroreflectivity is measured with:

2.29° observation angle corresponds to the viewing distance of the driver of 30m

1.24° illumination angle

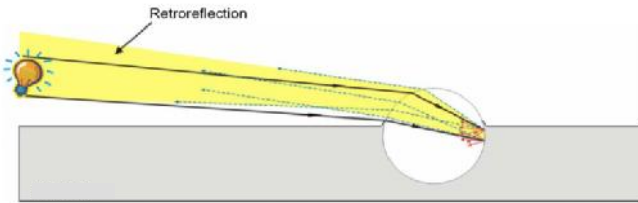
The measured value is:

$$R_L = \text{mcd/m}^2/\text{lux}$$

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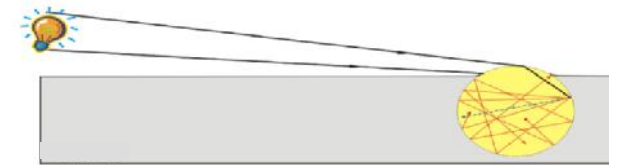
How does retro-reflectivity work on line marking?



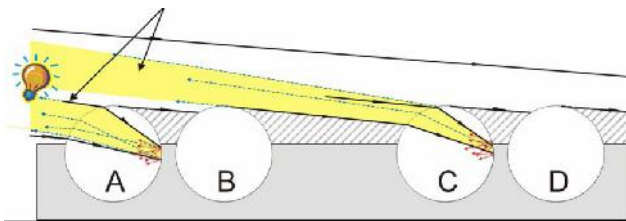
For flat Lines Approximately 50-60% embedded into material for best retro reflectivity



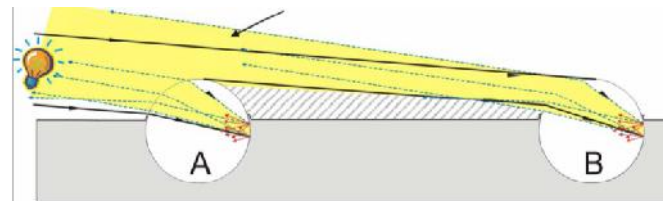
Not deep enough
→ no retro reflection



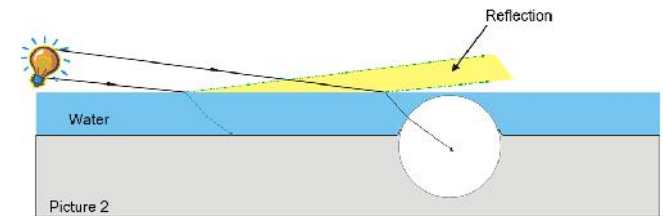
To deep → retro reflection gets lost inside of the glass bead



Excess of glass beads
A and C retro reflects the light best
B and D are in the shadow of glass bead A and C no light will reach them → no retro reflection

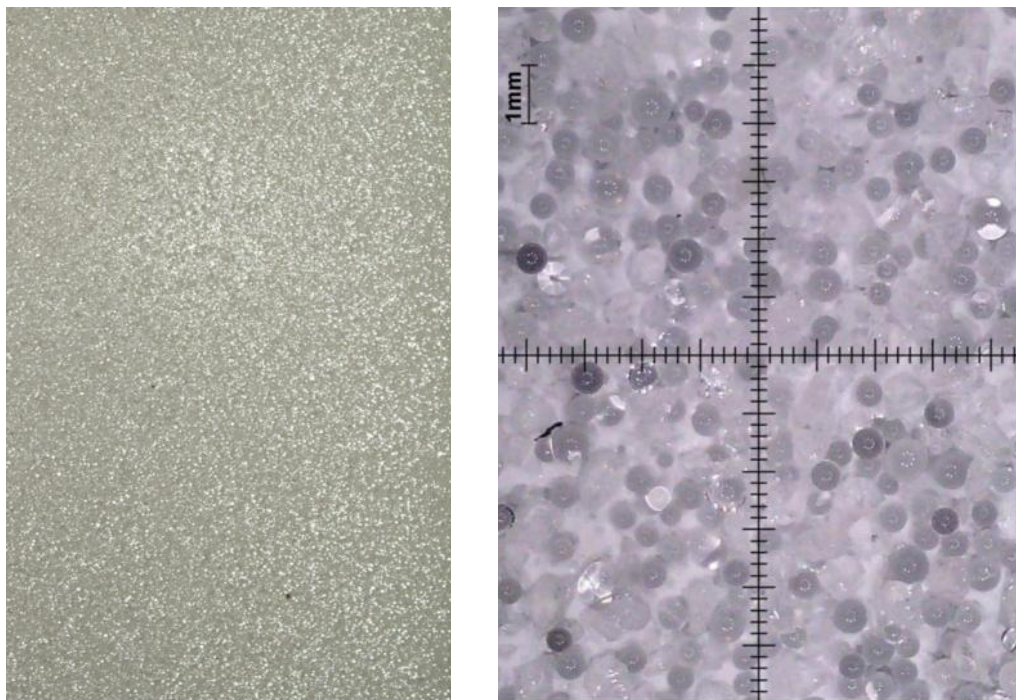


... the right amount of glass beads
Distance A to B 6mm for 300 micron beads
Distance A to B 21mm for 1200 micron beads



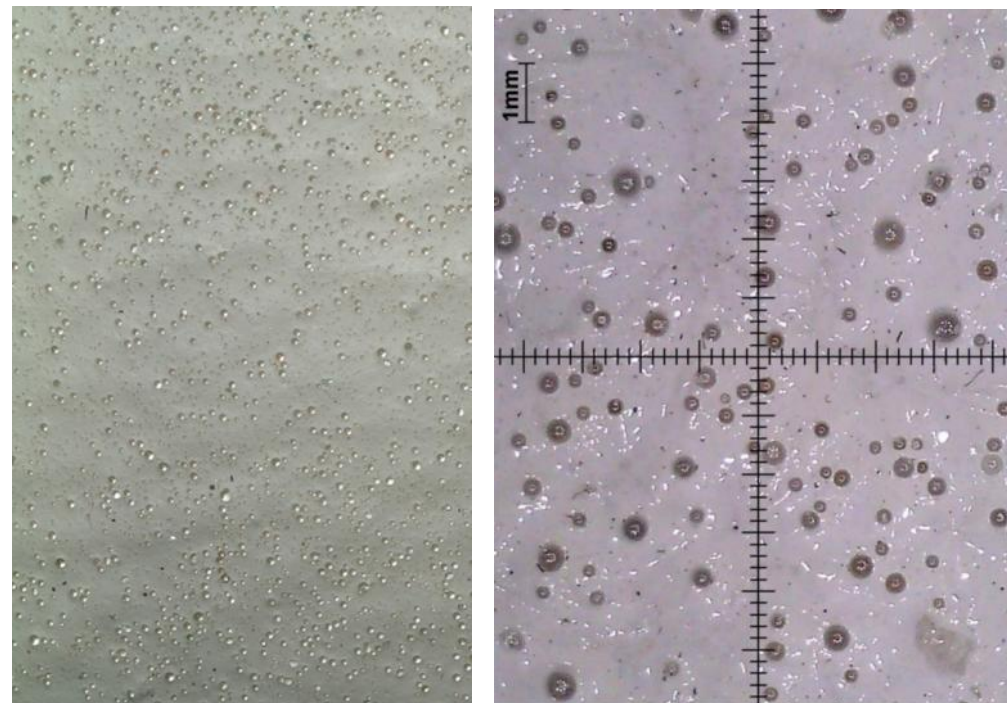
Water film → causes specular reflection; line disappear

High bead-application



R_L 63

Correct bead-application



R_L 1295

Over beading cost more and reduces R_L

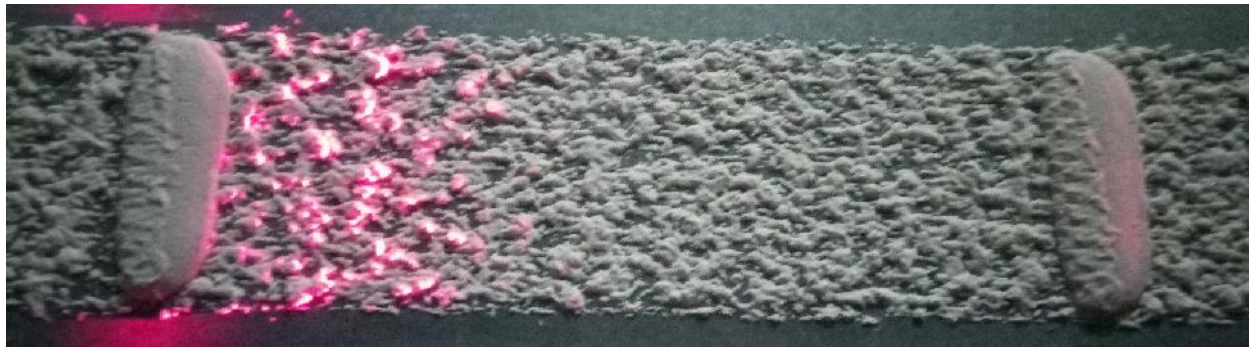
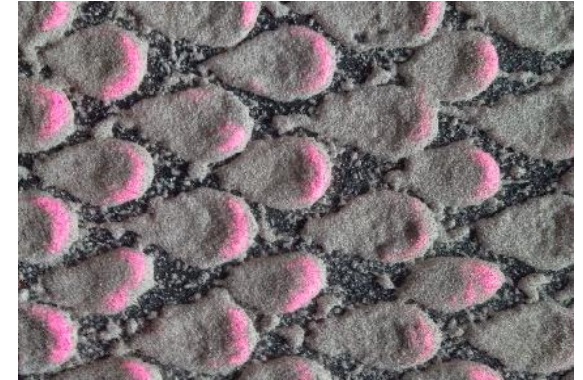
30 meter road-marking Illumination



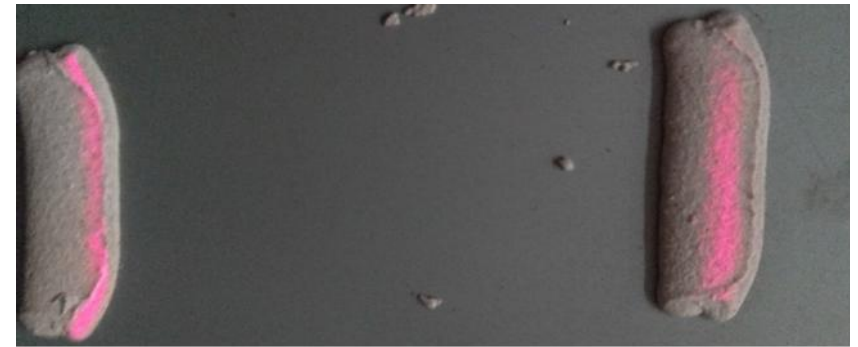
Illumination under 1.24° from the right hand side

Multi dots and structure markings are
Ideal to drain the water of the line
They produce higher R_L in the wet even
with having less illuminated area than a
flat marking

Those markings work better with small
or micro beads



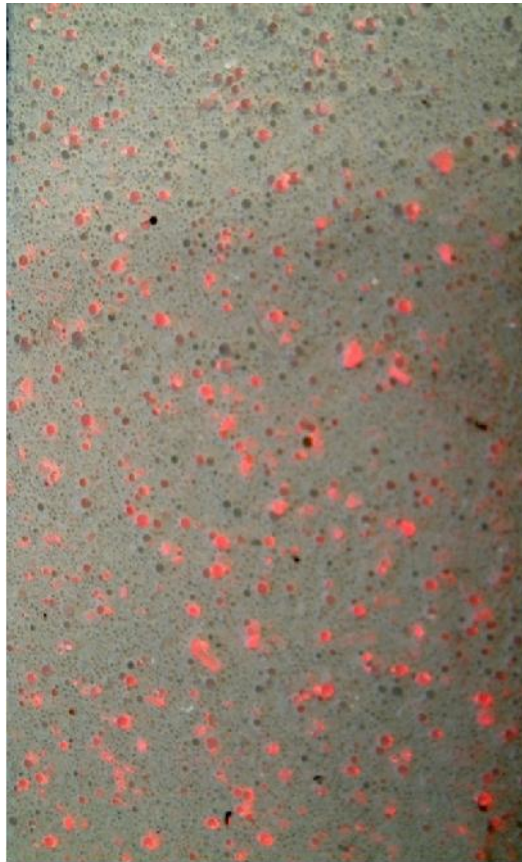
ATP structure marking 500mm centre



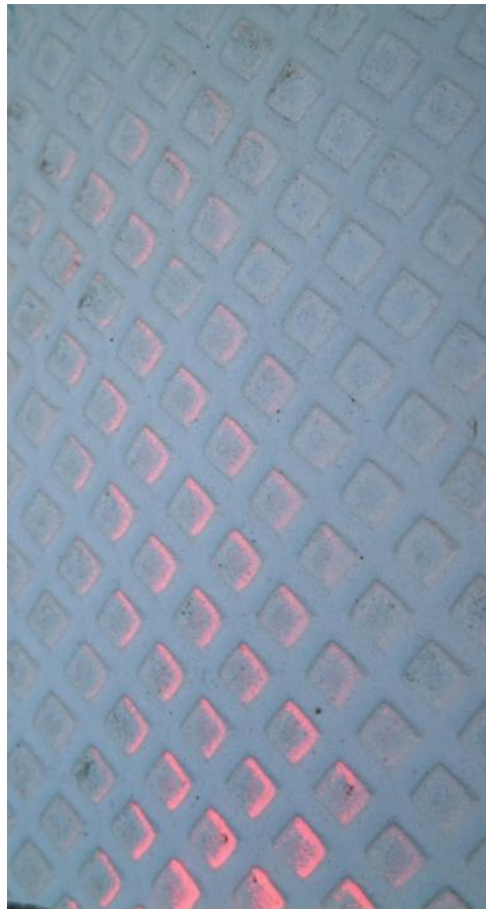
ATP only marking 250mm centre

Only illuminated areas can produce retro-reflectivity

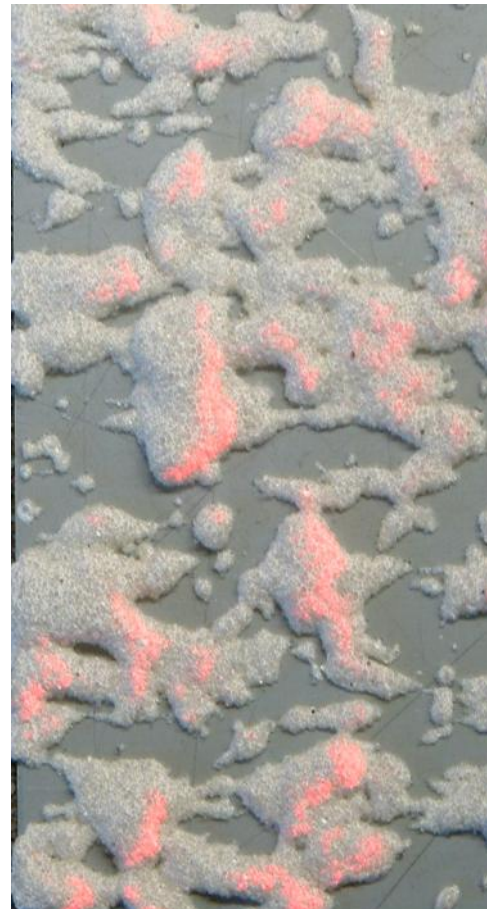
30 meter geometry road-markings Illumination



Paint & Type D beads



Drain channel & micro beads



Structure marking
intermix beads



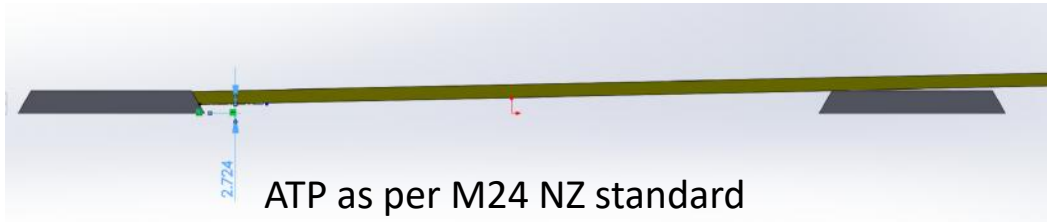
Type D & micro beads

Only illuminated areas can produce retro-reflectivity

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Retro-reflectivity on ATP



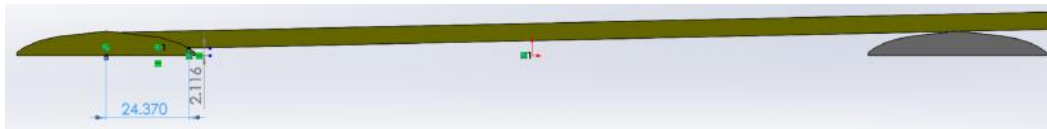
Height	7mm	If line would be painted over 1m length
Width	150mm	0.150m ² produces retro-reflectivity
Length	50mm	0.030m ² for theoretical ATP only $\frac{1}{5}$ of
Spacing	250mm	area



Actual shape of ATP

Only first half of ATP can produce RL

Most R_L is produced by specular reflectivity



0.015m² can produce R_L
 $\frac{1}{10}$ of the area of a flat line



0.0075m² can produce R_L if ATP only

$\frac{1}{20}$ of the area of a flat line

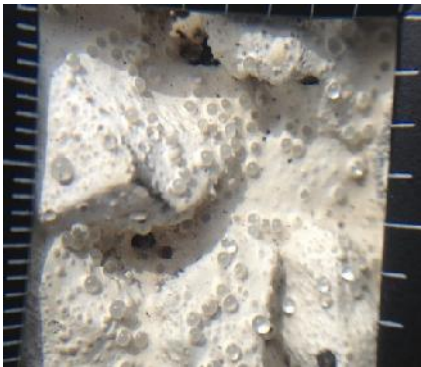
0.0525m² can produce R_L if ATP and Baseline

$\frac{1}{3}$ of the area of a flat line

Only illuminated areas can produce retro-reflectivity

Low retro-reflectivity why?

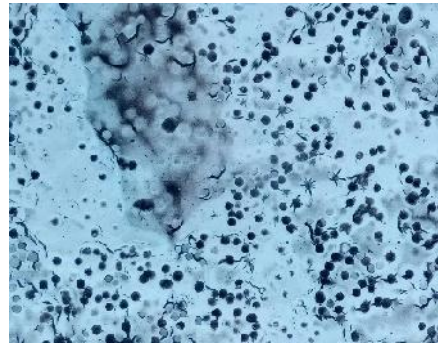
- Measured too early after application (over-beaded, paint overspray)
- Application issues (gun blockage; too many beads)
- Low quality beads (black, un-round and crushed beads)
- Wrongly coated beads
- Paint runs down into voids not enough paint left on top of chip
- Unsuitable material application (not embeaded properly, too viscous material, too thin paint application)
- Scouring of beads (glass to soft lots of gravel, sand on road)
- High traffic loads on Line marking (roads going uphill with lots of traffic crossover, overtaking and merging lanes, tight curves)



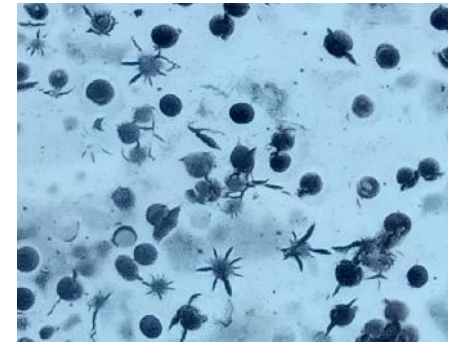
Low retro-reflectivity



Incompatible material does not bind to baseline



Wrongly coated beads
Not deep enough



Beads which are still in paint contain over spray

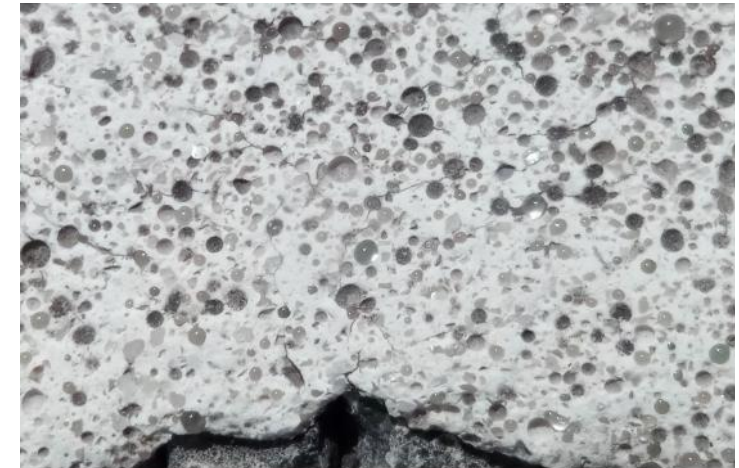


On ATP it is very important to choose the properly coated beads and the right bead size.

Big beads do not work as part of retro reflectivity is produced by specular reflectivity.

ATP material has High viscosity so beads have to be forced in to the material.

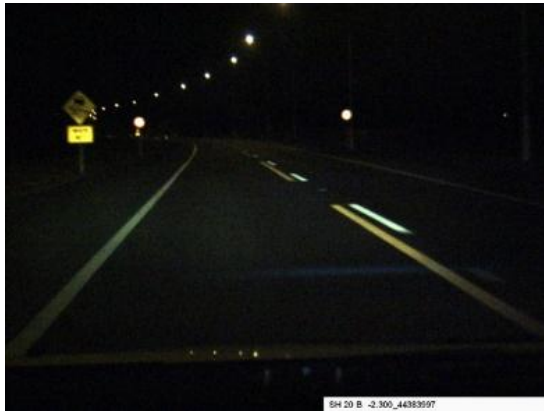
Big beads will only stick to top of material and fall out quickly under load



Zwahlen's recommended minimum RL values

Vehicle Speed		Minimum Required R_L [mcd/m ² /lux]			
		Without RRPMs		With RRPMs	
		3.65 s Preview Time/ Distance		2.0 s Preview Time/ distance	
60 km/h	16.6m/s	R_L 50	60.59m	R_L 30	33.20m
90 km/h	25.0m/s	R_L 170	91.25m	R_L 35	50.00m
105 km/h	29.1m/s	R_L 340	106.21m	R_L 50	58.20m
120 km/h	33.3m/s	R_L 620	121.54m	R_L 70	66.60m

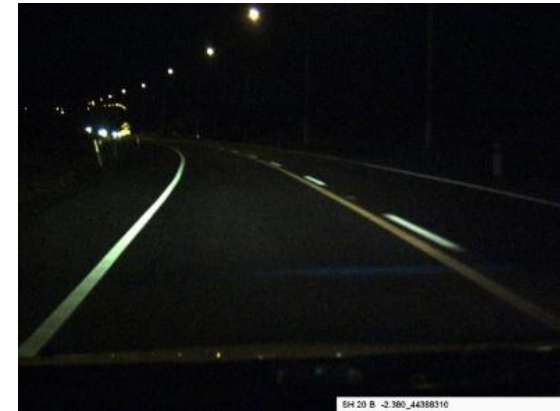
Typical braking distance for 100km/h = 98m/**122m wet**



70



150



340

Zwahlen, H. T. and T. Schnell. *Pavement marking Visibility Research and Proposed Values for Minimum Required Pavement marking Retro Reflectivity*. Unpublished report, Department of Industrial and Systems Engineering, Ohio University Athens, Ohio. August, 1998

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Requirements of R_L in different countries.

2.4.1 Testing of Retro Reflectivity (NZ NOC contract)

After 1 month but before 2 months after application, the marking shall be clearly visible for a forward distance of 150m, or as far forward as possible until obstructed by the road geometry if less than 150 m, when viewed from a vehicle at night (with lights on full beam) in the absence of overhead lighting.

Guesstimate produces low quality outcome

Performance Criteria (per TS45 Cl 6.1.1)

- | | |
|--|---------------------------|
| a. Minimum Retroreflectivity between 10 and 20 days of wear: | 350mcd/lux/m ² |
| b. Minimum Retroreflectivity between 360 and 380 days of wear: | 300mcd/lux/m ² |
| c. Minimum Retroreflectivity at any time after 380 days of wear: | 150mcd/lux/m ² |

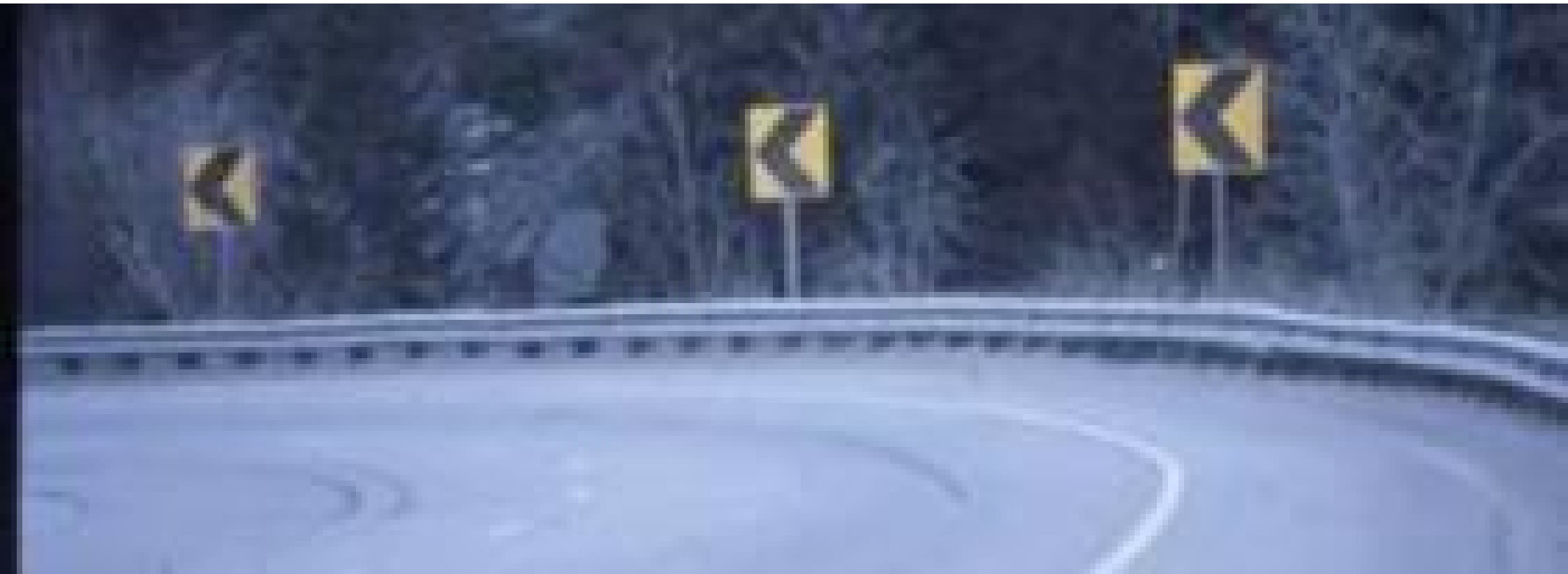
Actual measuring performance based outcome

What gets measured, gets managed

Peter Tucker



Why worry about retro-reflectivity?

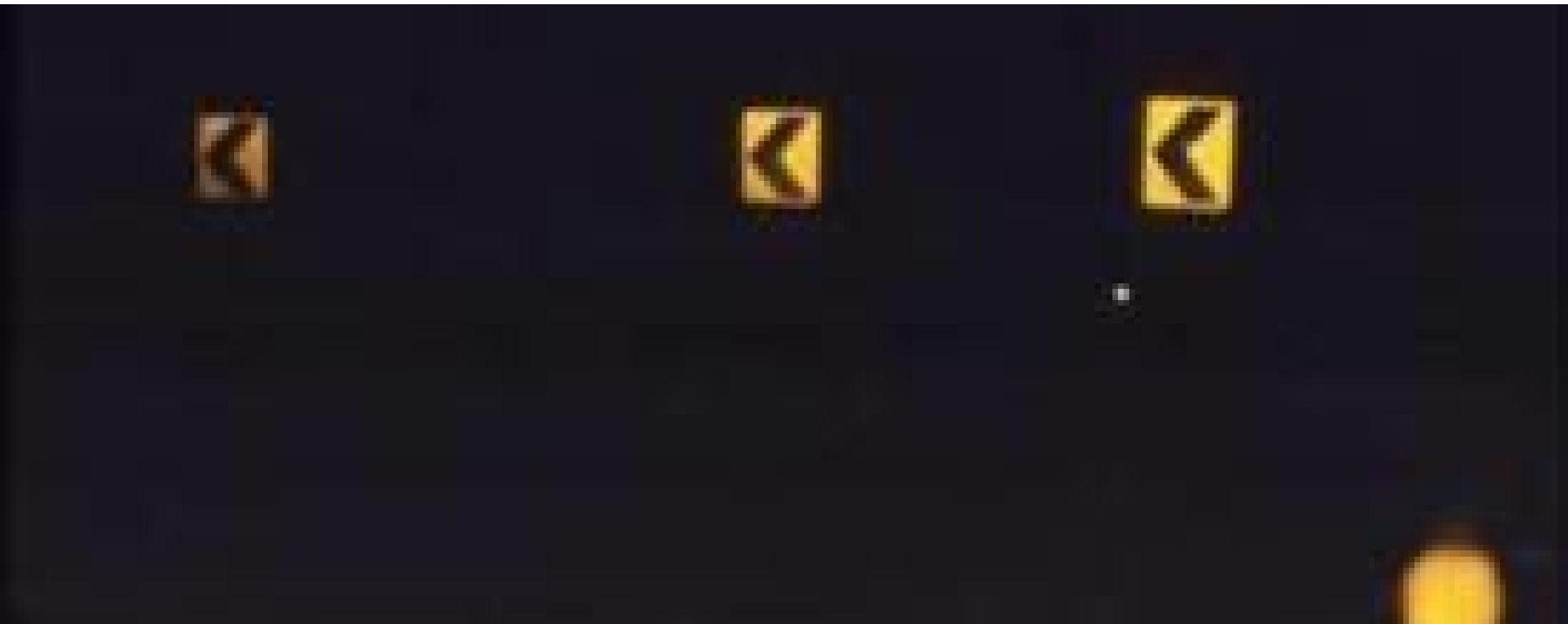


90% of information is processed visually

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Why worry about retro-reflectivity?



Visual performance in darkness drops to **5%**

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What is the real efficiency of road markings

In 2007, Road Safety Marking Association (RSMA) published the report « **White Lanes Save Lives** » which provided a cost-effectiveness Analysis of new road markings in selected counties. Eg : Cheshire County County decided to apply a wet-night visible marking on a section of the A556 highway which had recorded 16 personal injury accidents during the last three years at an estimated cost of 1'400'000 £. (3'270'000 NZD)

Status	Total accidents	Serious accidents	Minor accidents	Wet-dark accidents
Before Implementation	16	2	14	4
After Implementation	6	0	6	0

Cost of new Road marking : £ 20 000

(48.000,- NZD)

\$3'000'000.00 saving for a \$50'000.00 investment

Good value for Money



Wet night visible road marking



- Painted line covered by rain disappears
- Wet night road marking keeps retro-reflectivity going in rain

High quality road-marking can save lives



Achieved through high Standards and quality control
Measuring not guessing

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Thank you

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- FHW
- 3M
- RSMA
- Zehntner